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Protecting Towed Hydrophone Arrays from Marine Attack

Weak-Electric and Near-Field Acoustic Causes — Biological Countermeasures

Final Report submitted to the Office of Naval Research by Dr. Ad. J. Kalmijn and his Graduate Student, Ivan Fernando Gonzalez

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Introduction

Scientific research on marine attack caused by weak-electric and low-frequency acoustic fields of hydrophone arrays and their towing vessels has led to a thorough understanding of the problem and the development of the necessary countermeasures. Based on the progress made, we have designed sea tests to be conducted prior to implementation in the fleet.

The proposed sea tests were to benefit greatly from our capable Graduate Student, Ivan Fernando Gonzalez, who was prepared to carry out the long series of trials to be executed together with the P.I. Ivan has a strong background in ocean physics and sensory biology. He was eager to make the project part of his doctoral thesis at our institution.

Ivan has now been trained in preparation of his task at sea. After the first explorations, I had expected him to work in the field for two consecutive seasons, first with me and my project engineer, then on his own with the aid of an undergraduate engineering student. Between cruises, he would process the data and prepare the next series of experiments.

Below, I will give a short outline of the overall project, with the understanding that the Ivan was going to focus on the skills and knowledge needed to execute the tests at sea. Ultimately, as the P.I., I was to remain responsible for his training and for the work at sea, the execution of which I had largely to leave to Ivan, which I did with great confidence.

Unfortunately, the project was discontinued after the first year due to a lack of funding after Schlumberger, a main partner in the grant endeavor, was no longer able to provide the funds needed for completion of the work. The project will be continued as soon as new partners join in the undertaking, hopefully in time before serious loss of preparedness.

The Objectives Were

- To prevent ocean predators from inflicting damage on towed hydrophone arrays by (i) removing their causes and (ii) applying biologically designed counterfields.
- To bring many years of innovative research to fulfillment and to prove ONR's wisdom of calling upon pure science to resolve the most difficult practical problems.

The Work Statement Was

- To identify the weak-electric and low-frequency acoustic fields produced by hydrophone arrays and their towing vessels, by physical measurement.
- To determine the propensity of the measured fields to guide sharks into the vicinity of the arrays and provoke them to bite, by behavioral methods.
- To design weak-electric counterfields to divert the animals or to render the sensory cues offered by the arrays nonsensical, by our computer algorithm.

- To test the recommended array changes and the efficacy of the countermeasures prior to implementation in the fleet, under real-life conditions at sea.

The Equipment and Facilities Were

- The array fields are measured in the SIO Electromagnetic Research Facility, the Faraday Laboratory, under well-controlled electric and magnetic ambient field conditions.
- The laboratory behavioral studies are conducted in the magnetically clean geodesic dome, part of the Faraday Laboratory Complex in a remote, quiet part of the SIO campus.
- The approach algorithm program constitutes a computer implementation of the animals' electric and near-field acoustic orientation mechanisms expressed mathematically.
- The tests at sea are conducted by use of our mobile working platform to track sharks in simulated array fields in the shallow waters of the Sea of Cortez or Bimini Bay.

The Methods and Procedures Were

- Weak-electric fields are measured with low-noise DC electrodes and preamplifiers. Low-frequency acoustic fields are measured with differential pressure transducers.
- Behavioral experiments are conducted in response to parts of arrays and to electrically or acoustically simulated arrays, and video recorded for quantitative evaluation.
- The proprietary approach algorithm program is a most powerful tool for the design of counterfields and the prediction of the animals' orientational responses.
- The mobile working platform is a sophisticated 'laboratory at sea' featuring electric-field production and measurement capabilities and an optical shark tracking system.

The Planned Sea Tests Were

When on station, we will track sharks by optically following their movements by means of a telescope, mounted on top of the platform's tall observation tower and connected to an on-board computer. The computer will plot the paths of the animals on its screen.

When the animal's course has been fixed by the computer, we will apply the array field to be tested, predict the animal's path on the basis of our computer algorithm, and compare the path that the animal actually takes with the path that the algorithm predicts.

The computer will by the statistical method of sequential analysis in real time calculate the goodness of fit of the path predicted by the algorithm to the path taken by the animal. The results will ascertain the propensity of the array field to cause marine attack.

Then, we will, in the presence of the offending array fields, apply the counterfields we have designed to make the sharks veer off, repeatedly bite phantom prey, or to render the sensory cues presented by the array otherwise biologically nonsensical.

It is important to note that the counterfields will be on the same order of strength as the fields produced by the vessel and its arrays, or even weaker. The fields must be that weak to be taken by the sharks for those of real ocean currents, enemy, or prey.

These, in brief, are the sea tests to be conducted in order to bring the shark-bite project to completion and to prepare the counterfields for implementation in the fleet. We expect to accomplish our task, after half a year of preparation, in two years of sea tests.

Research Conducted in the first Half-Year Period

To start the sea tests in the spring of 2003, and to make the graduate student thoroughly familiar with the working platform, the equipment, and the test procedures, we have:

- Prepared the working platform, the specially designed Boston Whaler which I have used for similar work for many years in shallow waters and in the open ocean.
- Begun building the optical tracking system, the electric-field simulation and measurement system, the on-board instrument control and statistical data processing system.
- Implemented and behaviorally tested the newly designed counterfields in our land-based research facility prior to subjecting them to full-scale tests at sea.
- Prepared exploration of the Sea of Cortez for a suitable test site, to be used in preference of Bimini Bay for logistic reasons, to reduce cost, increase efficiency, and save time